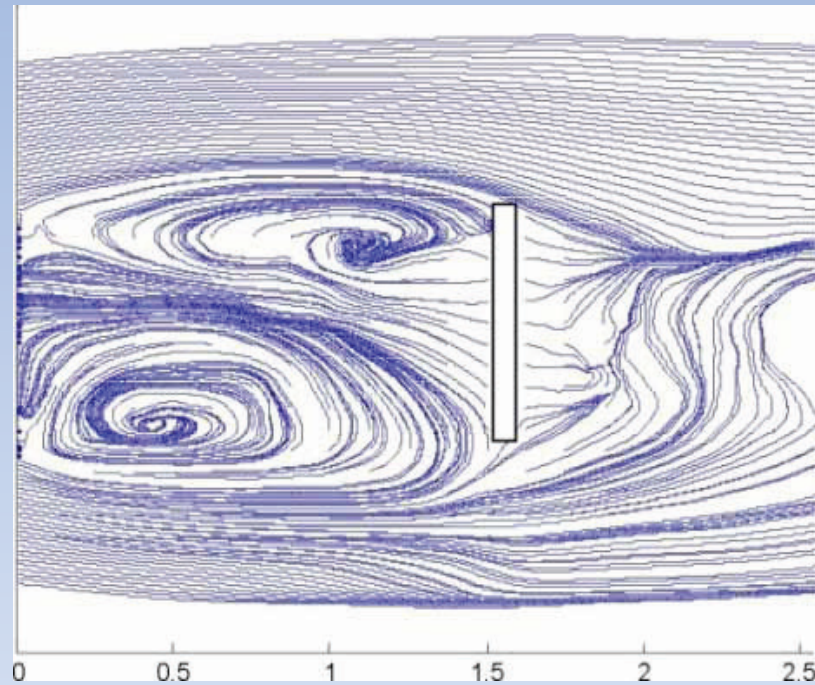


Study and Control of Flow past Disk, and Circular and Rectangular Cylinders aligned in the Flow

Hiroshi Higuchi
Syracuse University

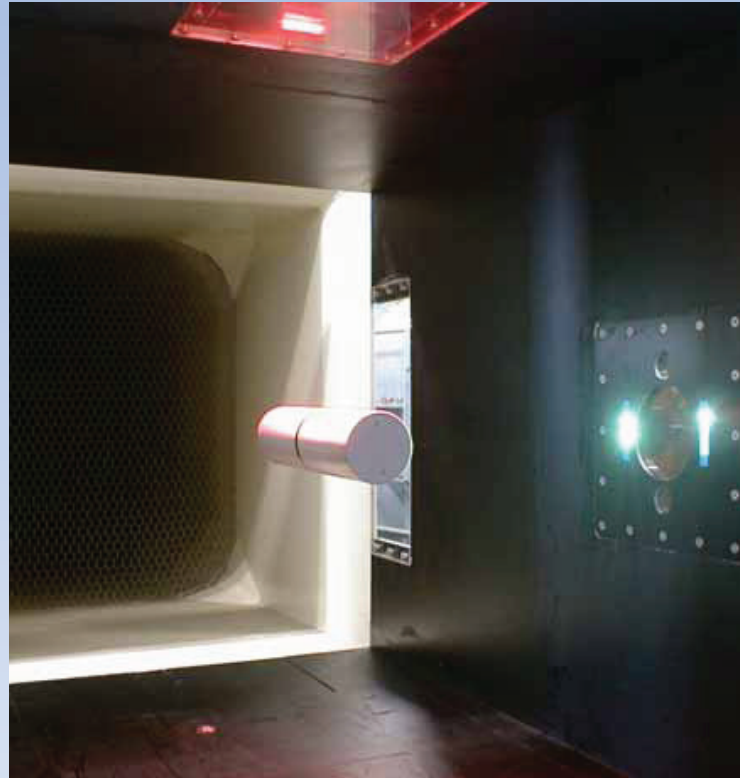
- Disk in Tandem Configuration
- Circular Cylinder in Axial Flow
- Rectangular Cylinder in Axial Flow
- Cube
- Polygonal Plate (Triangular, Square, Hexagonal, Octagonal)
- Disk Wake Control (Open Loop)
- Disk Wake Control (Toward Feedback)

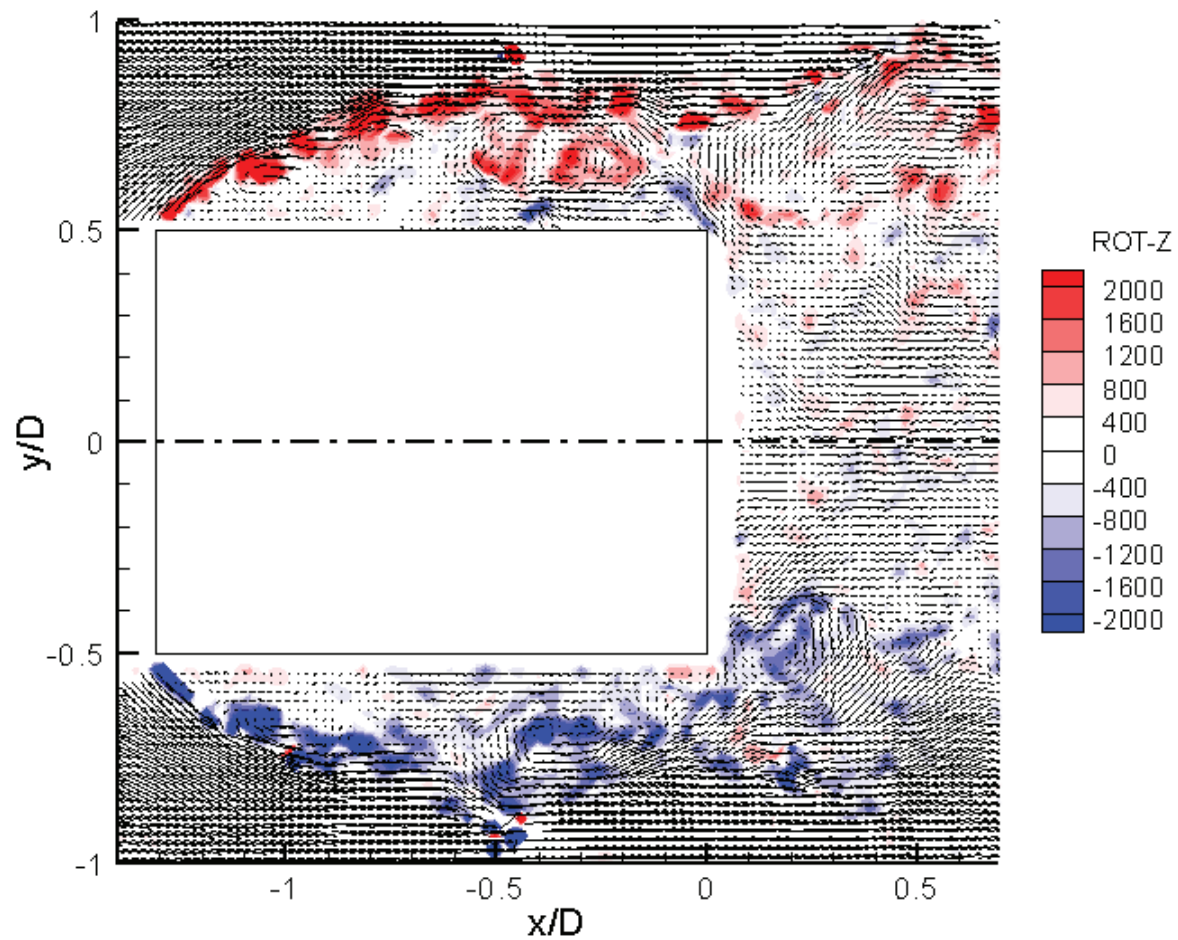
Two Tandem Disks

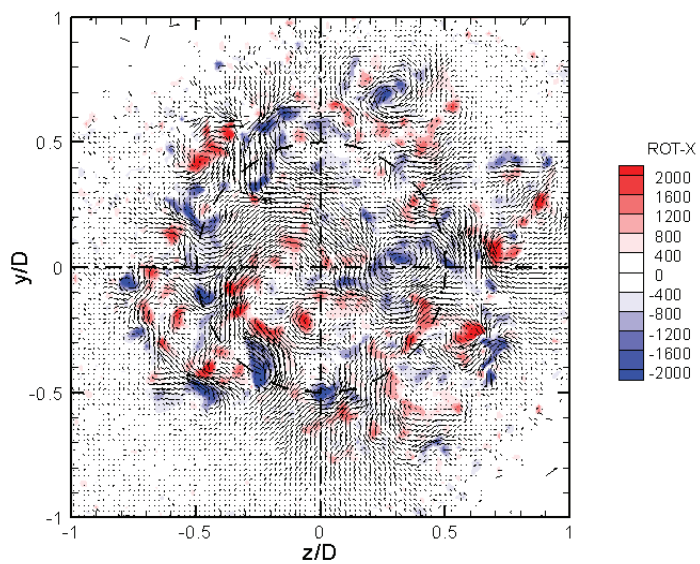
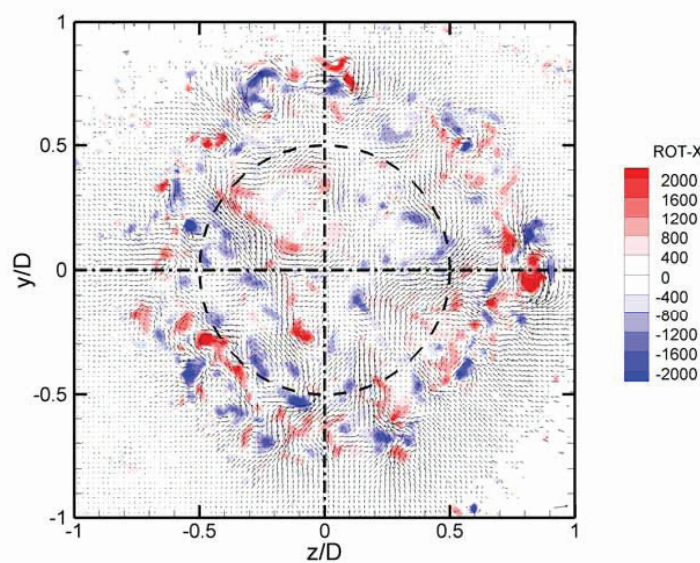


Streamlines of the flow past two disks in tandem.
(Gap 1.5 times the disk diameter. $Re=2200$, PIV in water.)

Magnetically suspended Test Cylinder in the wind tunnel

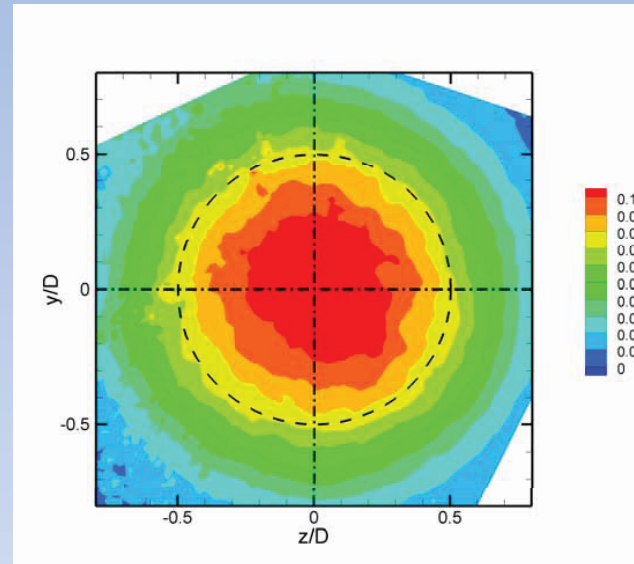
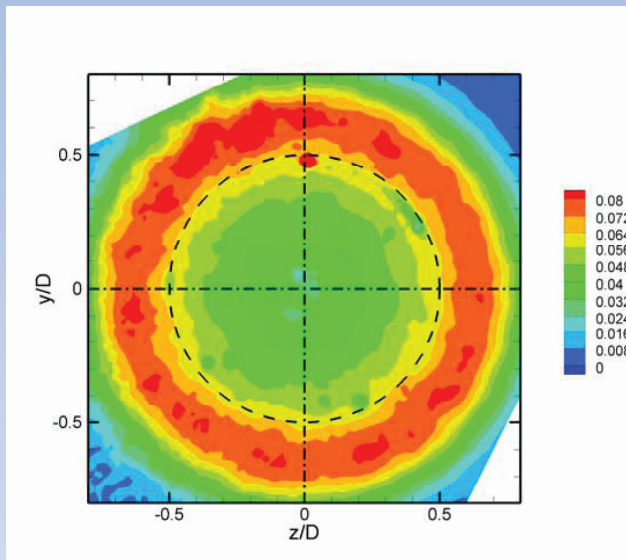


**Instantaneous Vorticity and Velocity Field** $L/D=1.31$, $Re=100,000$

(a) $L/D=1.31$,(b) $L/D=1.68$

Instantaneous Vorticity and Velocity Field in the Cross-Flow Plane of the Wake at $x/D=0.33$ (units of vorticity 1/s)

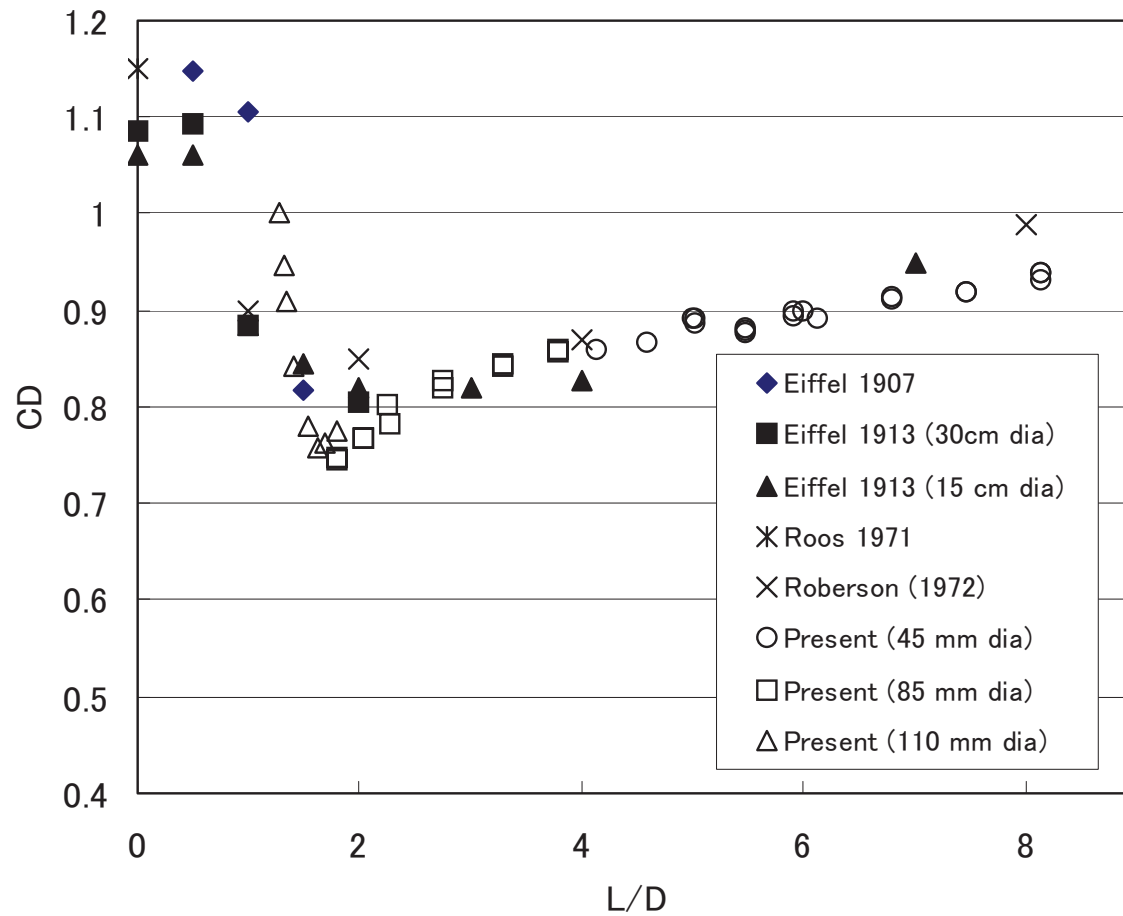
Higuchi et al, JFM 2008



Ensemble-averaged mean-square turbulence distribution
behind $L/D = 1.31$ model, $v^2 + w^2/U^2$:

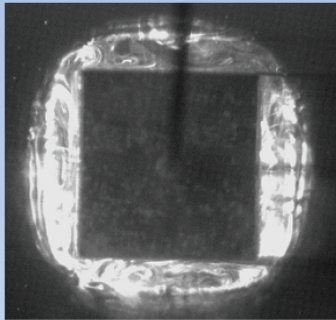
(a) $x/D = 0.33$

(b) $x/D = 1.5$.

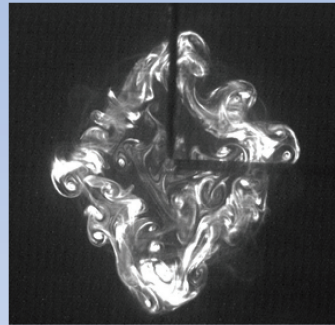


Summary of Drag Variation with Fineness Ratio

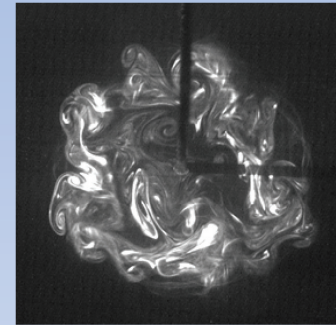
Flow past a Rectangular Cylinder



$x/H=0.4$

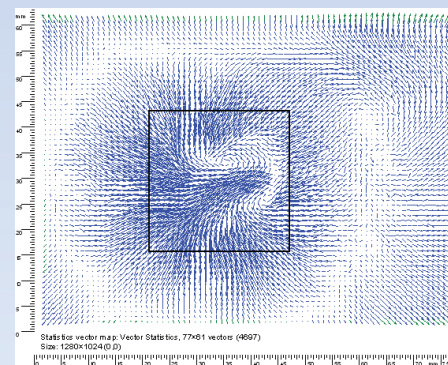
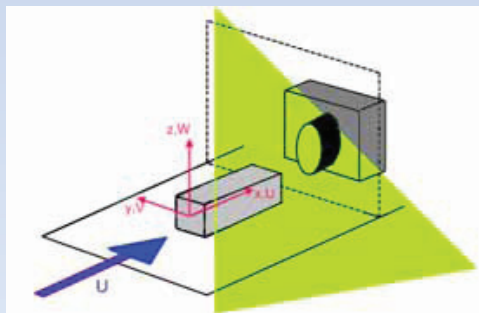


$x/H=1.6$

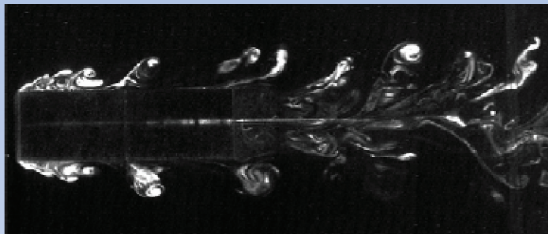


$x/H=1.8$

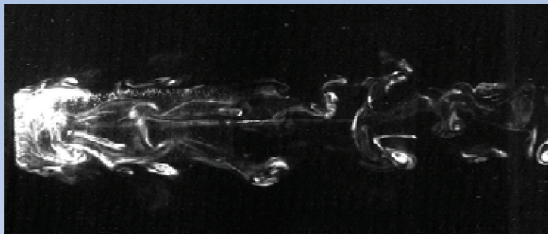
Visualization behind a square cylinder $L/H=1$ at various cross-flow planes ($Re=1900$)



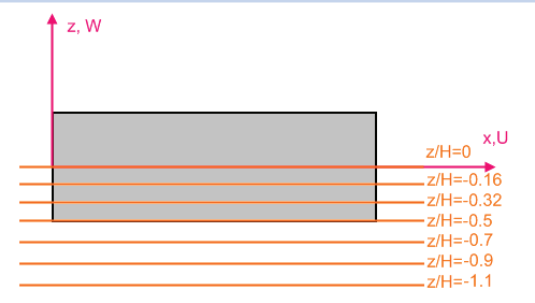
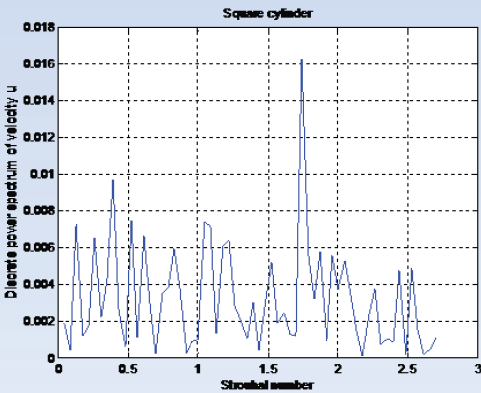
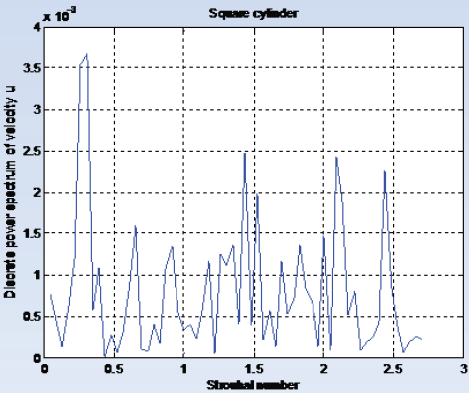
Flow past a Rectangular Cylinder (cont'd)



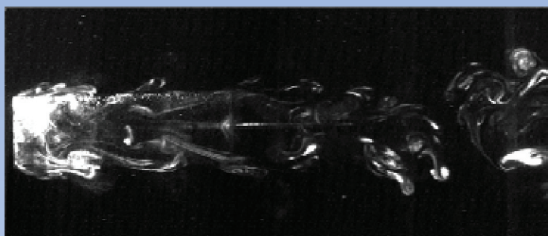
$z/H = -0.16$



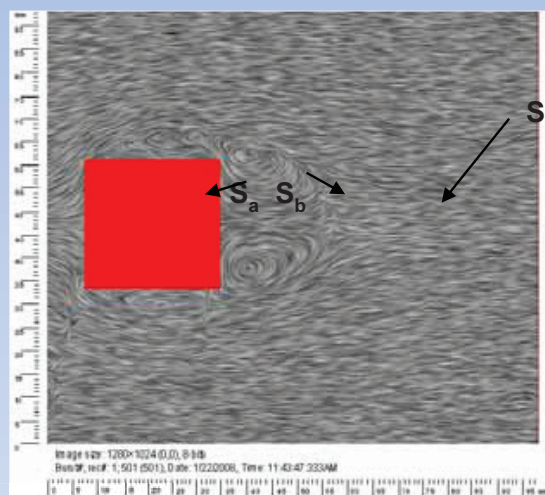
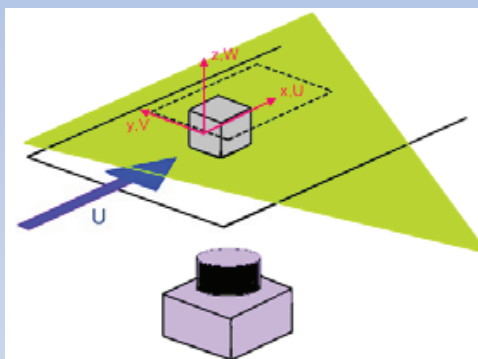
$z/H = -0.5$



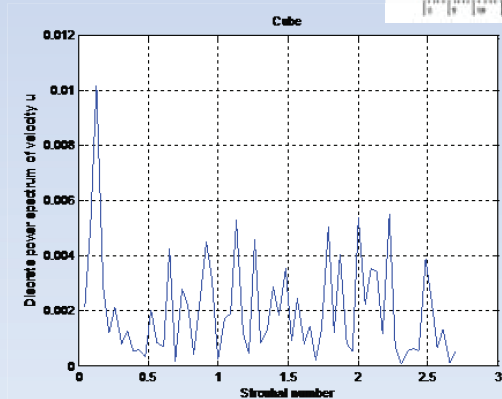
Flow past a Cube



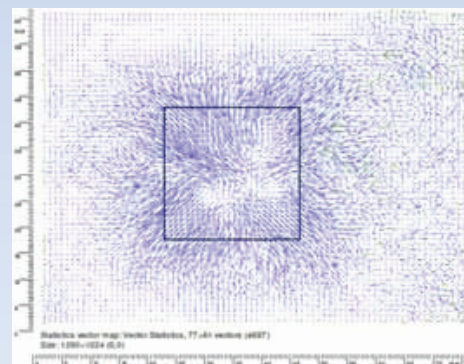
Overall flow vis.



Mean velocity



PSD from TR-PIV at $x/H=3$



$x/H=1.39$



Square2.avi



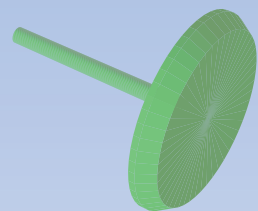
Wake forming behind a square plate.
Higuchi-Anderson

Disk Wake Control



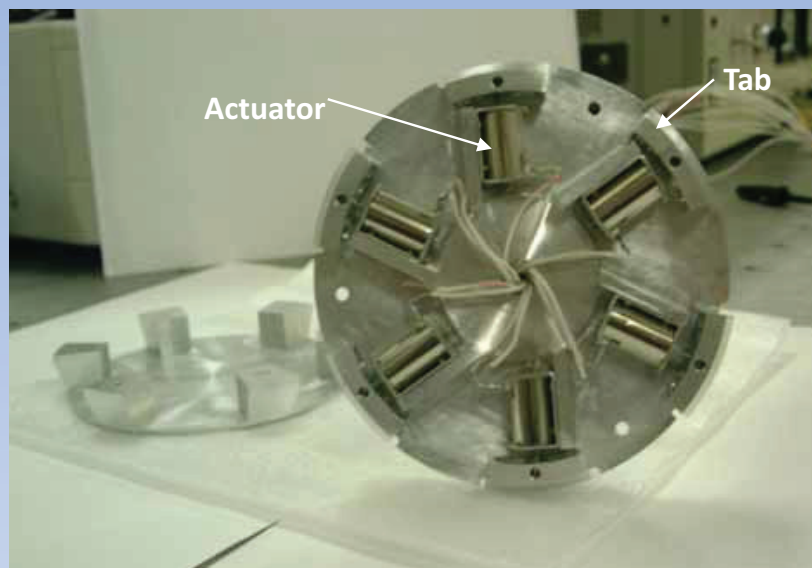
HHHBDiskAPS.mov

Open-loop Control of Disk Wake



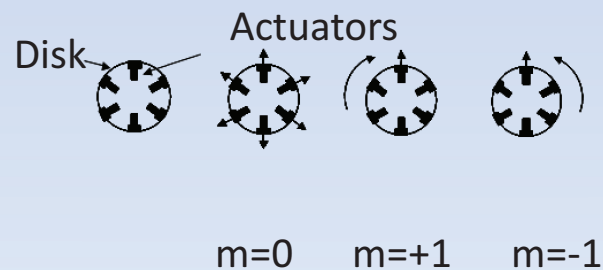
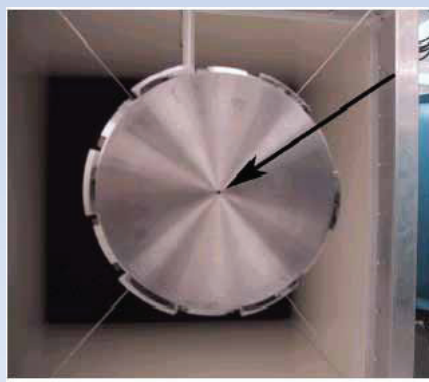
Model geometry

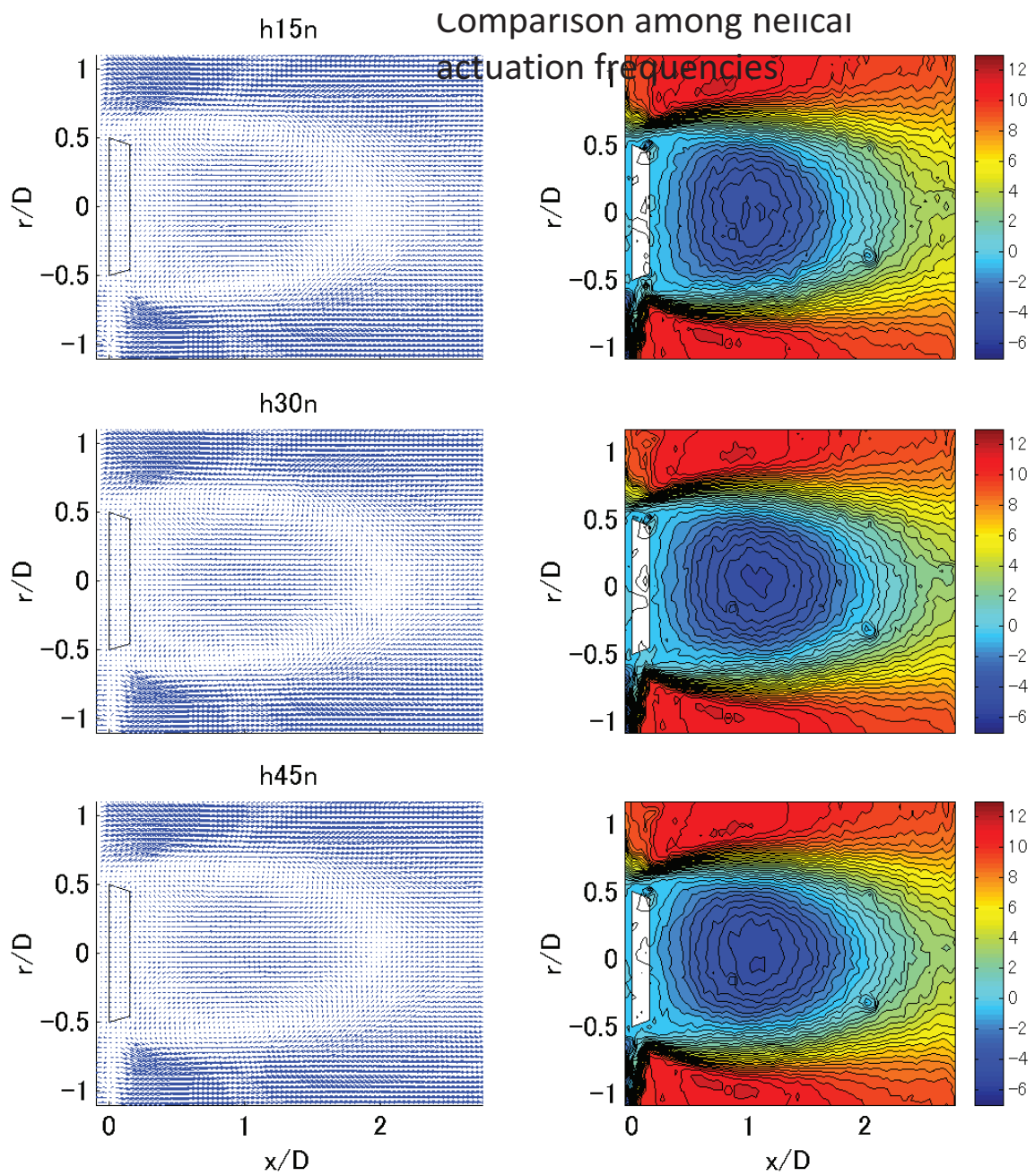
(Front diameter 100mm and rear 92mm)

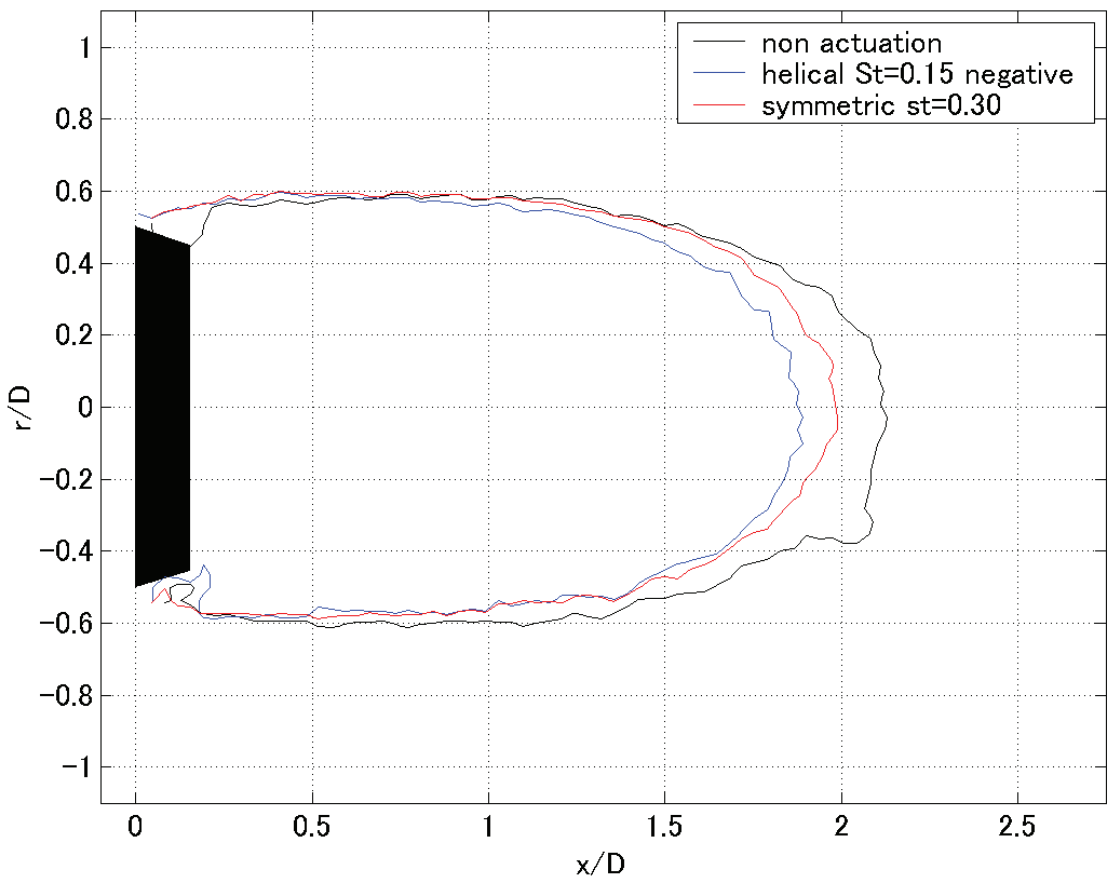


Interior of the disk showing
6 electro-magnetic actuators

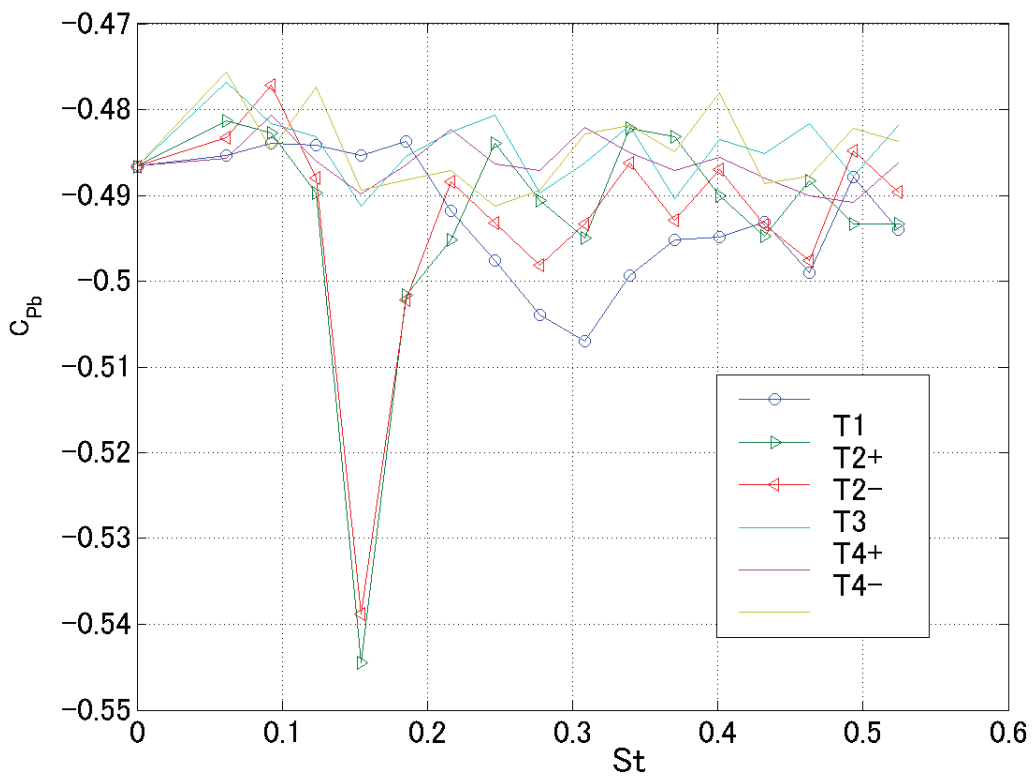
Pressure tap



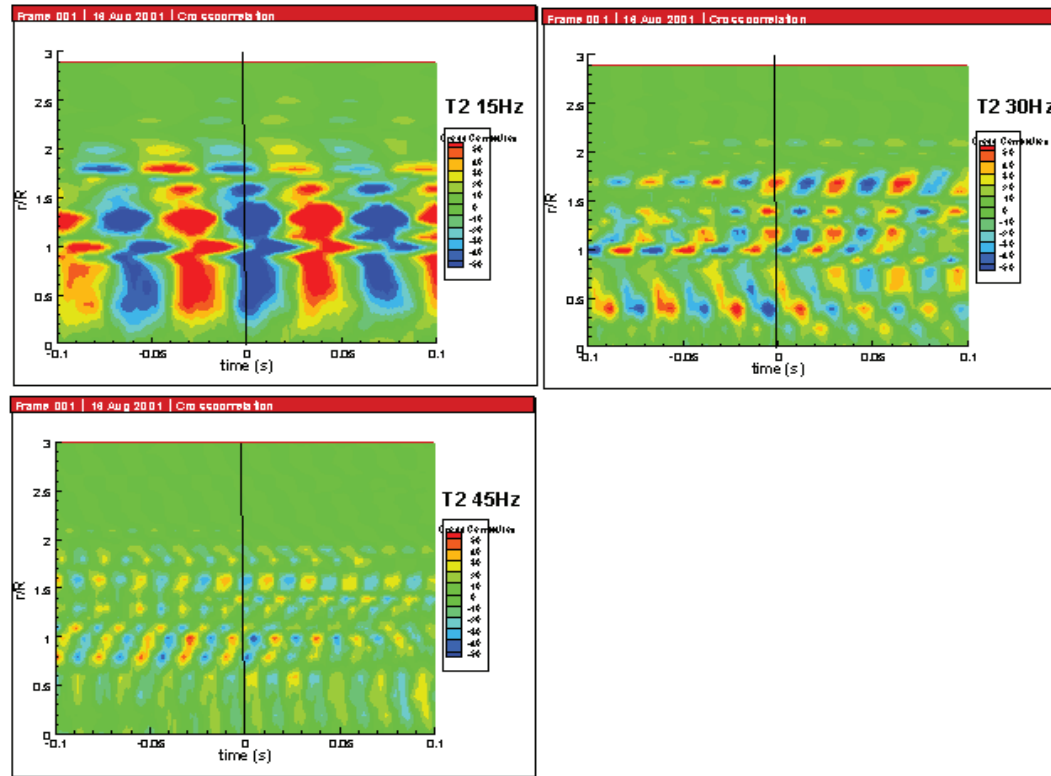




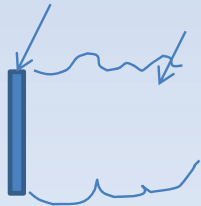
Base Pressure Variation with Excitation Modes



$$C_{Pb} = \frac{P_{base} - P_{\infty}}{P_0 - P_{\infty}}$$



Actuator tabs



Hot wire probe

Cross correlation between the tab actuation and the velocity in the wake.

Helical actuation at x_1 , x_2 and x_3 times the natural frequency.

Closed-Loop Feedback Control of Disk Wake

With M. Glauser, M. Fardad
Students; Z. Berger, Z. Orbaker

- Methodology similar to that used for our closed-loop control of Separation over NACA 0012 Airfoil (Pinier et al, AIAA Journal 2007)
- Synthetic Jet Actuators, Miniature Pressure Transducers
- Split POD with and without Actuations
- Flow state estimation from Pressure signature

Original Fluctuating Velocity Field

(Time-Resolved PIV in water, Bigger & Higuchi 2009)

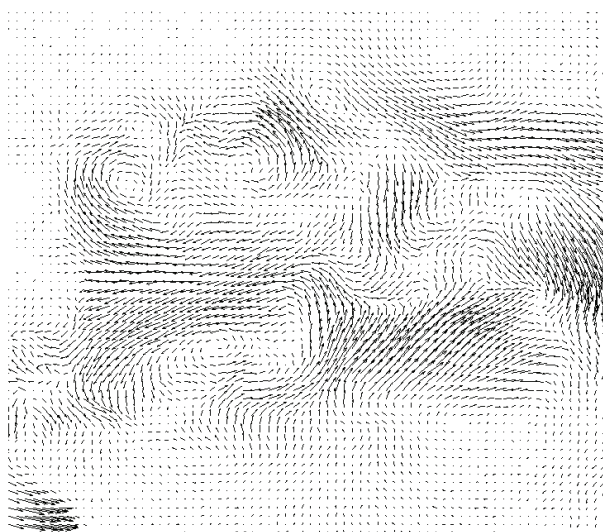
$$u_{fluct}, v_{fluct}(x, y, t)$$

General POD Reconstruction

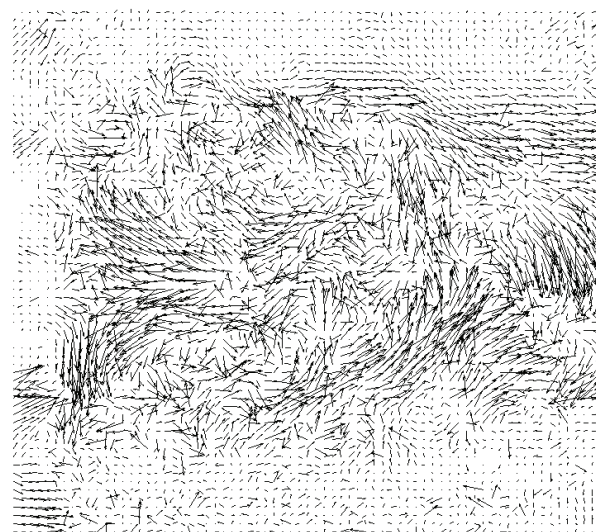
$$u^m, v^m(x, y, t) = \sum_{k=1}^m a^k(t) \phi^k(x, y)$$

m specifies the number of modes in the POD reconstruction

20 Mode POD Reconstruction



POD Reconstruction; 20 modes



Actual Fluctuating Velocity Field

Z. Berger et al, to be presented at APS DFD 2009